

USE OF EDUCATIONAL GAMING AND SIMULATION AS TEACHING TOOLS IN HEALTH SCIENCES

By

Farhan R. Soomro

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ABSTRACT

Background

Use of educational gaming and simulation as teaching tools has been growing exponentially. Despite their increase in use, their adoption in the health sciences as teaching tools is limited. This review of the literature critically examines published evidence on the use of educational gaming and simulation in the health sciences, highlights their strengths and limitations, and provides possible future research directions.

Objectives

To assess, systematically, published peer-reviewed articles on the use of educational gaming and simulation related to post-secondary students' knowledge, retention, and confidence and/or mastery in clinical skills in health sciences.

Methods

A systematic search was conducted in PubMed, CINAHL, E.R.I.C., the Cochrane Databases of Systematic Reviews, and Web of Science from January 2005 to August 2015. All publications identified through searches were assessed by a single reviewer for relevance and only studies published in English were selected. Studies were limited to systematic reviews of experimental and quasi-experimental studies, RCTs, experimental pretest-post-test design, and quasi-experimental design methodologies/approaches only. Articles that reported teaching tool other than educational gaming and simulation, and gaming and simulation not related to health education were excluded from this review.

Results

A total of 1595 articles were identified that were published on educational gaming and simulation. Out of 1595, 195 were redundant, and only 22 studies were found relevant based on specific inclusion and exclusion criteria employed, which were included in this review.

Conclusion

This review of the literature provides evidence that the use of educational gaming and simulation as a teaching tool in health sciences have increased over the time. Both educational gaming and simulation were found to increase knowledge and skills but short-term and long-term retention were weak. In addition, educational gaming and simulation was found to be more enjoyable and preferred method as evaluated by students. However, additional research is warranted to assess their short-term and long-term effects on knowledge retention and skill acquisition.

KEY WORDS: Educational game, Educational gaming, Simulation and teaching strategy, simulation.

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SECTION 1

Background and Rationale

1. Background and Rationale

Educational games are defined as a set of competitive activities which consist of strict rules to reach desired goals such as acquiring or improving knowledge and skills (Boctor, 2012; Haggart, 2001; Webb, Simpson, Denson, & Duthie, 2012). They differ from non-educational games where the purpose is primarily entertainment. **Simulations**, like educational games, consist of a different medium of instruction where the act of imitating a situation, event, and/or environment closely mirrors the real world (Sinclair, 2009; Shephard, McCunnis, Brown, & Hair, 2010). Simulations may be presented by using a computer software and/or program to imitate a clinical scenario, a low to high-fidelity mannequin to imitate a real patient, or in a graphics/animation format to mimic a clinic or laboratory (Rosen, Hunt, Pronovost, Federowicz, Weaver, 2012). Here, the user interacts with the game to solve a real-life situation or a problem in a simulated environment. For example, a game which simulates a clinical scenario where a medical student attempts to problem solve and rescue a patient undergoing sudden hypotension (Kerfoot, 2014; Schumbert, 2013). This type of environment can be provided through serious gaming. A **serious game** is defined as a computer-aided application/software that is designed to engage, interact, and challenge user in a safe and fun way to learn the skills, knowledge or attitudes that can later be applied in reality (Graafland, Schraagen, & Schijven, 2012; Hannig, Kuth, Ozman, Jonas & Spreckelsen, 2012; Lancaster, 2014). They are designed for purposes other than entertainment and therefore, clearly differ from conventional video games. For example, “eMedOffice” is a serious game that teaches medical students how to set-up and design their own medical practice.

According to a report published by Pew Internet and American Life Project, 97% of 12-17 years-old and 53% of 18 years-old or older play online and video games, respectively (Lenhart,

Jones, & Macgill, 2008). Notably, 76% of students reported playing games (Lenhart et al., 2008), and nearly half of those games (i.e., 44%) were card, puzzle, arcade and word games (Grabstats, 2012). Like young adults, older adults also play games. In 2015, a report published by Entertainment Software Association (ESA) noted that the average gamer is 35 years-old; the vast majority of players (i.e., 74%) are 18 and above and almost half (i.e., 44%) of them are females (ESA, 2015). On average, their gameplay time varies from five hours to more than six hours a week (Grabstats, 2012; The NDP group, 2014).

Globally, there were 1.78 billion gamers in 2014 (Statista, 2014). Of the 1.78 billion, Asia Pacific has the largest numbers of world's gamers at 827 million, followed by Europe and the Middle East combined at 569 million, then North America at 195 million, and then Latin America at 185 million (Statista, 2014). Comparatively, Canada has one of the world's largest video gaming industries (ESA, 2014). Here, 54% individuals play video games and among those 81% are 13-17 years old and 64% are 18-34 years old, with 33 years old being the average age of the gamer. Collectively, these trends suggest that game playing activities have been growing exponentially, especially among millennials (also known as Generation Y or Digital Natives) (Baranowski, Buday, Thompson, Baranowski, 2008; Boctor, 2013; Girard, Ecalle, & Magnan, 2012; Prensky, 2001).

Millennials are individuals who were born in or after 1982, and represent current university and college students (Boctor, 2013; Robb, 2012). They are highly technologically competent, prefer multitasking, often communicate through digital devices (i.e., smartphones, PDAs, laptops, and tablets), and therefore, have different learning style preferences (Boctor, 2013; Pardue and Morgan, 2008). They are also heavy users of games at 30%, in comparison to their older counterparts (i.e., 36-49 years-old) at 17% (ESA, 2015). In recent years, their laptop usage has

also increased from 65.9% in 2006 to 82.2% in 2008 (Ghori, 2015). With the global increase in the gaming population dominated by millennials, it is predicted that the number of digital game users in Canada will increase from 8.6 million in 2015 to 12.93 million in 2020 (Statista, 2015).

Historically, educational games have been used as an educational tool for centuries (Bartfay & Bartfay, 1994). Simulation, however, is a new technique in comparison to games, but its use and acceptance as a teaching tool has been rapidly growing (Royse and Newton, 2007; Swiderska 2013, Thomason, Hart & Shaw, 2013). To date, many studies report their use as effective teaching tool in areas such as healthcare, business, military applications, and aviation training (Bartfay & Bartfay, 1994; Webb et al., 2012). In fact, games have been recognized as the second most utilized form of teaching (Anyanwu, 2014), and are part of almost every culture around the world (Kirriemuir & McFarlane, 2004). In nearly 25 years since their adoption, games have captured a big market and have become part of our everyday culture (Garris & Ahler, 2002). As a result, games are recognized as a multibillion-dollar global industry (Squire, 2008), with an estimated market of \$68.3 billion in 2012 (Hefflinger, 2008). This includes \$30 - \$75 million-dollar market in game-based training alone (Squire, 2008).

With the rise of experiential learning, the need to evaluate games for their educational benefits has been debated by both scholars and educators. Although introduced as a formal teaching tool more than 75 years ago, their use and acceptance in the health sciences is a relatively new phenomenon (Henry, 1997). Moreover, many health educators are reluctant to employ educational games and simulation as a teaching tool because of lack of noted time, knowledge regarding their use and effectiveness, and/or technological challenges (Khan, Telemesani, Alkhotani, Elzouki, Edress & Alsulimani, 2011). Consequently, this review will explore these noted gaps. First, a brief history of gaming and simulation will be provided. Second, its effects on learning outcomes will

be critically examined. Third, the strengths and limitations of educational games and simulations will be highlighted. Lastly, a discussion regarding the conclusions and implications for health educators will be highlighted, along with directions for possible future research.

SECTION 2

Review of the Literature

2. Review of the Literature

2.1. Methods

A systematic search strategy was created to identify potentially relevant articles in the following databases: PubMed; Cumulative Index to Nursing & Allied Health Literature (CINAHL); the Cochrane Databases of Systematic Review; Educational Resources Information Centre (E.R.I.C); and the Web of Science from January 2005 until August 2015. Due to the surge in interest in educational gaming and simulation in health sciences during the past decade, search was limited to past 10 years only. A secondary literature search was also conducted which entailed reviewing the reference lists of the primary sources for potential additional articles.

2.2. Inclusion and Exclusion Criteria

Articles published in English only from January 2005 to August 2015 were retrieved and screened for relevance and possible inclusion. Some articles were also included from the secondary literature search that were outside of the 10 year focus due to their relevance and value for this review. Studies were limited to systematic reviews of experimental and quasi-experimental studies, randomized controlled trials, experimental pretest-post-test design, quasi-experimental design methodologies/approaches only. Articles that reported a teaching tool other than educational gaming and simulation, and gaming and simulation not related to health education were excluded from this review. In addition, studies were excluded if participants were health professionals themselves and not students pursuing post-secondary education per se. Moreover, editorials, reports, letters and non-peer reviewed reports were also excluded. Only those studies that were conducted on humans were included. The search strategies for CINAHL and E.R.I.C. were similar to those used in the PubMed search. Flow charts 1 and 2 below show the databases

searched and potential articles retrieved for “educational game”, “educational gaming”, “educational gaming and health sciences”, and “simulation and teaching strategy”, respectively.

2.3. Search Results:

The primary search revealed 1587 total potential articles, of which 195 were redundant abstracts. The secondary literature search yielded 8 additional abstracts. Hence, a total of 1595 potential abstracts were located. However, only 22 were related to the use of educational gaming and simulation and/or addressed their effectiveness as teaching tools in the health sciences. The sample sizes in the studies located ranged from 5 minimum to 250 maximum students. These studies were mostly systematic reviews of experimental or quasi-experimental studies, experimental pretest-post-test design types, and/or randomized control trial designs. Only one study was cross-sectional in nature. Data abstraction templates (Table 2) were employed to summarize information related to author, year, country, design, and major findings/outcome of all the selected and retrieved articles. The 22 studies identified as relevant will be described in greater detail below, along with their strengths and limitation, and implementation for health educators.

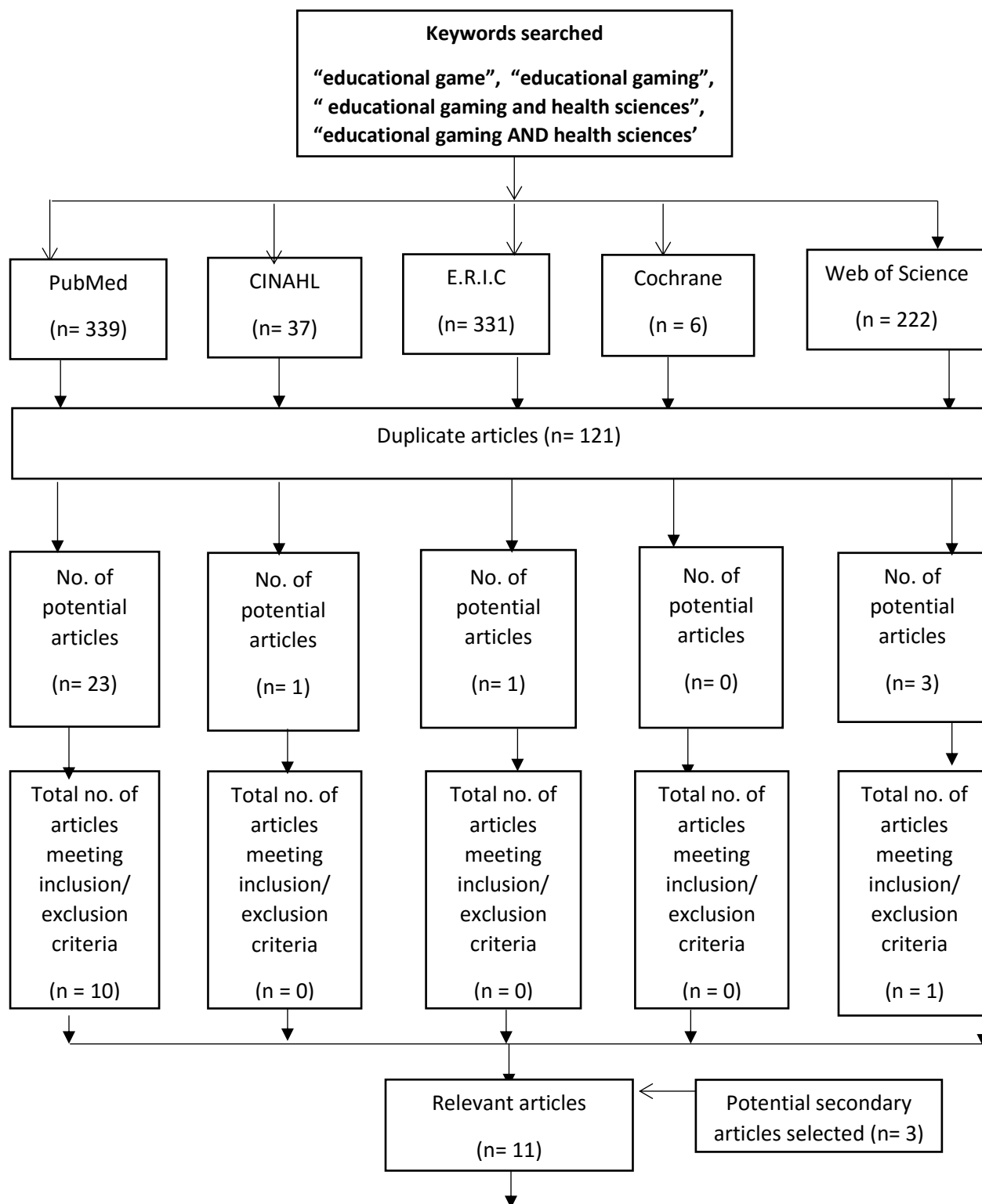
2.4. Ranking Method:

Rank I represents the strongest evidence in the ranking hierarchy which consists of systematic reviews and meta-analyses of randomized control trials (RCTs) or non-randomized control trials. Rank II includes evidence that is derived from a single randomized control trial or a non-randomized trial. Rank III consists of evidence that comes from systematic reviews of observational and/or correlational studies. Rank IV includes a single observational or correlational study. Rank V includes systematic reviews of descriptive or qualitative study. Rank VI studies are classified as a single physiological, descriptive or qualitative study. Lastly, rank VII evidence, which is the lowest quality of evidence in the hierarchy, comes from personal opinions of expert

and/or panels or committees (Bartfay & Bartfay, 2015). This ranking system reflects the Cochrane Collaboration systematic review criteria.

Of the 22 studies selected for this review, 17 were ranked II, three were ranked as I, one was ranked III, and one was ranked as IV.

Flow chart 1. Systematic search strategy for key search terms listed below



2.5. A Brief History of Gaming and Simulation:

Gaming is as old as civilization itself (Henry, 1997). There is a rich history of gaming for both recreational and educational purposes which dates back several millennia (Bartfay & Bartfay, 1994; Pauli, 2005). Game artifacts such as clay tablets, wall paintings, and a variety of wooden and stone game pieces have been recovered from the remains of ancient civilizations. Collectively, these artifacts provide evidence that board and table games, for example, were commonly played by ancient civilizations (Blakely, Skirton, Cooper, Allum & Nelmes, 2009; Crist & Vaturi, 2014; Howell, 1969). In Egypt for example, a game called “Senet” (photo 1), was played to win a race to the finish point (Wolfe, 1998); although some researchers argue that it was played to practice divination (Crist and Vaturi, 2014). Similarly, modern day chess is reported to have originated from an ancient Chinese war game called “Wei-hai” (photo 2), which was played to train military personnel on war tactics and decision making skills (Bartfay & Bartfay, 1994).



Photo 1. A replica of an ancient Egyptian board game Senet (Source: Canadian Museum of History, Ottawa. ON. Photo by Farhan Soomro, 2015).

Moreover, many authors claim that gaming was employed as a tool to socialize, communicate and educate individuals as far back as 5000 B.C.E to 3000 B.C.E (e.g., Bartfay & Bartfay, 1994; Blakely et al., 2009; Wolf & Crookall, 1998; Webb et al., 2012). These authors also suggest that gaming was, in fact, a very popular social and recreational activity that was played and enjoyed by all ages and socioeconomic classes. Their uses, however, were mainly noted for recreation, military and physical training, and/or to practice divination. For example, the still popular game Snakes & Ladder ® (Milton Bradley Company, United States, 1943) (photo 3) was played in ancient Egypt to teach moral values and social standards. Similarly, cube dices and seal stones



Photo 2. A modern day chess game which has its origin from an ancient Chinese war game Wei-hei (Source: Canadian Museum of History, Ottawa. ON. Photo by Farhan Soomro, 2015).

discovered from ancient Indian civilizations provide evidence that games were utilized to teach both hunting and farming skills. They were also used to promote physical education such as running, jumping, martial arts, and dancing (Howell, 1969). It has been argued that the current use of educational gaming and simulation as a teaching tool can be traced back to the ancient war game of chess (i.e., Wei-hei) (Bartfay & Bartfay 1994; Henry, 1997).

were first employed for a student pilot training program during the late 1920s (Bland, Topping, Wood, 2011).

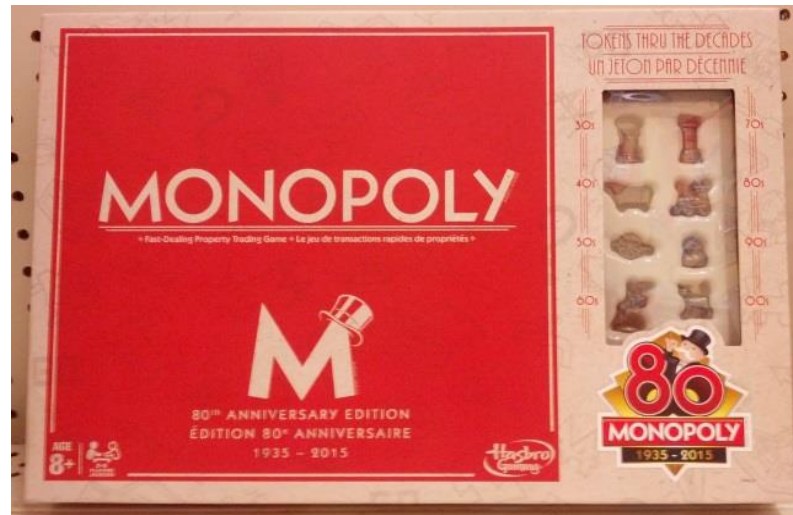


Photo 4a. Showing commercially available board game Monopoly® (Parker Brothers, United States, 1935), (Photo by Farhan Soomro, Oshawa, ON. 2015).

Similarly, the use of a tank simulators to train soldiers and other war personnel have been employed by armies globally for over 25 years (Garris & Ahlers, 2002). By contrast, in academia the interest in educational games and simulations were not realized until the 1980s when the corresponding video game revolution came to fruition (Boctor, 2013). Their popularity, however, has constantly grown since this period (Boctor, 2013; Pauli, 2005; Wilson, Bedwell, Lazzara, Salas, Burke, Estock, Orvis & Conkey, 2009). For example, the popularity of games-in-education as a discipline increased during 2003, when Massachusetts Institute of Technology (MIT), U.S.A., announced an initiative to explore their role in education (Moursund, 2006).

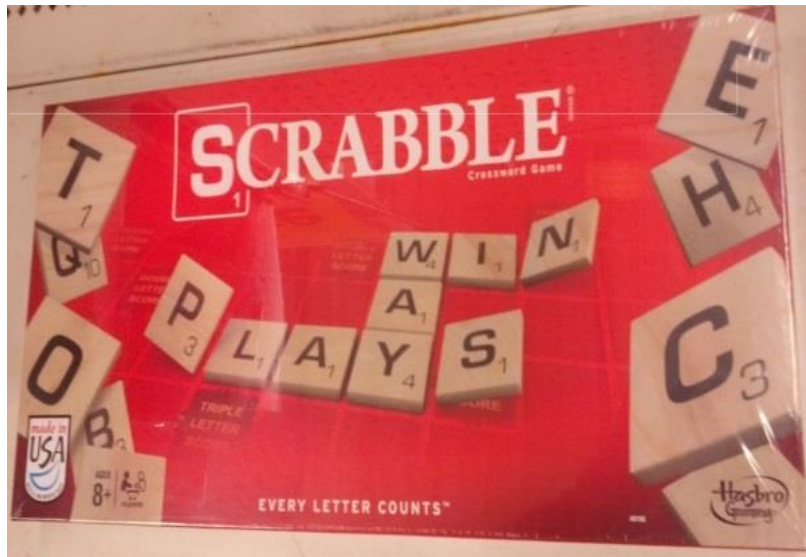


Photo 4b. Showing commercially available board game Scrabble ® (Parker Brothers, Hasbro Inc. United States, 1999) (Photo by Farhan Soomro, Oshawa, ON., 2015).

Wilson and coworkers (2009) argue that the reason for the late shift of games in education could be that they were long perceived for their entertainment value rather than their potential educational value.

In addition, some studies have even reported negative impacts associated with playing violent games on personality traits and behaviour (e.g., hitting, bullying and addictions) (Conolly, et al., 2012). Nonetheless, interest regarding the positive aspects associated with educational gaming and simulations (e.g., increase motivation, engagement, and increase knowledge retention), has been growing exponentially over the past few decades. This explains the growth and potential that games and simulations hold as innovative teaching methods and approaches.



Photo 4c. Showing commercially available board game Sea Battle inspired from the original game “Battleships ®” by Milton Bradley Company, United States, 1967. (Photo by Farhan Soomro, Oshawa, ON., 2015).

According to The American Society for Training and Development (ASTD), gaming and simulation organizations spend in excess of \$129 billion annually in gaming and simulation-based training programs globally (Wilson et al., 2009). This growth suggests that the use of educational games and simulation as a teaching tool is being increasingly employed and accepted. However, their use in the health sciences is still a relatively new phenomenon. According to Gaba et al., (2001), the fully mannequin-based interactive patient simulator for the training of medical/health sciences students was first developed during the late 1960s. Nonetheless, they were only formally adopted as the preferred clinical simulation training tool during the 1980s (Royse & Newton, 2007). Their use is particularly valuable for health care professional programs (e.g., nursing, medicine and dentistry) to train students in controlled, safe, and replicable mock settings or

situations. For example, many nursing programs can emulate cardiac arrest on realistic mannequins that can replicate vital signs including respirations, pulse and blood pressure (Figure 5a, 5b, 6 & 7). Moreover, their application in the health sciences is not just limited to simulators or computer-based applications, board and table games are also equally popular. For example, Jeopardy-type games and other quiz-type game formats are employed to teach, assess, monitor, and provide feedback to students in the health sciences



Photo 5a. Human mannequins in a U.O.I.T/Durham College clinical nursing simulation laboratory which replicate real patient's body functions, conditions or medical devices (e.g., Tracheostomy, pace-makers, colostomy). Photo by Farhan Soomro, Oshawa, ON., 2015).



Photo 5b. Human mannequin in a Durham College clinical nursing simulation laboratory, which replicates real patient body functions, conditions or medical devices (e.g., Tracheostomy, pace-makers, colostomy. Photo by Farhan Soomro, Oshawa, ON., 2015).

(Boctor, 2013; Khan, Telmesani, Aalkhotani, Elzouki, Edress & Alsulimani, 2011; Royse & Newton, 2007; Schuh, Burdette, Schultz & Silver, 2008).

These aforementioned authors (e.g., Boctor; Khan et al., Royse et al., and Schuh et al.) argue that gaming is superior to traditional lectures. For example, Boctor (2013), suggests that a game can promote critical thinking and enhance collaboration among students. Royse and Newton (2007), report that gaming as a teaching tool can improve knowledge retention and make learning more enjoyable. Similarly, Khan et al., (2011), found that while both teaching styles (i.e., Jeopardy-type game format and didactic lecture format) are equally effective, the game format was superior in terms of long-term retention of knowledge, and was the preferred format of teaching by students. These findings were consistent with Schuh et al., who also report that game-type

interactive educational activities were found to be more effective in improving students' knowledge, in comparison to faculty-based didactic lectures.

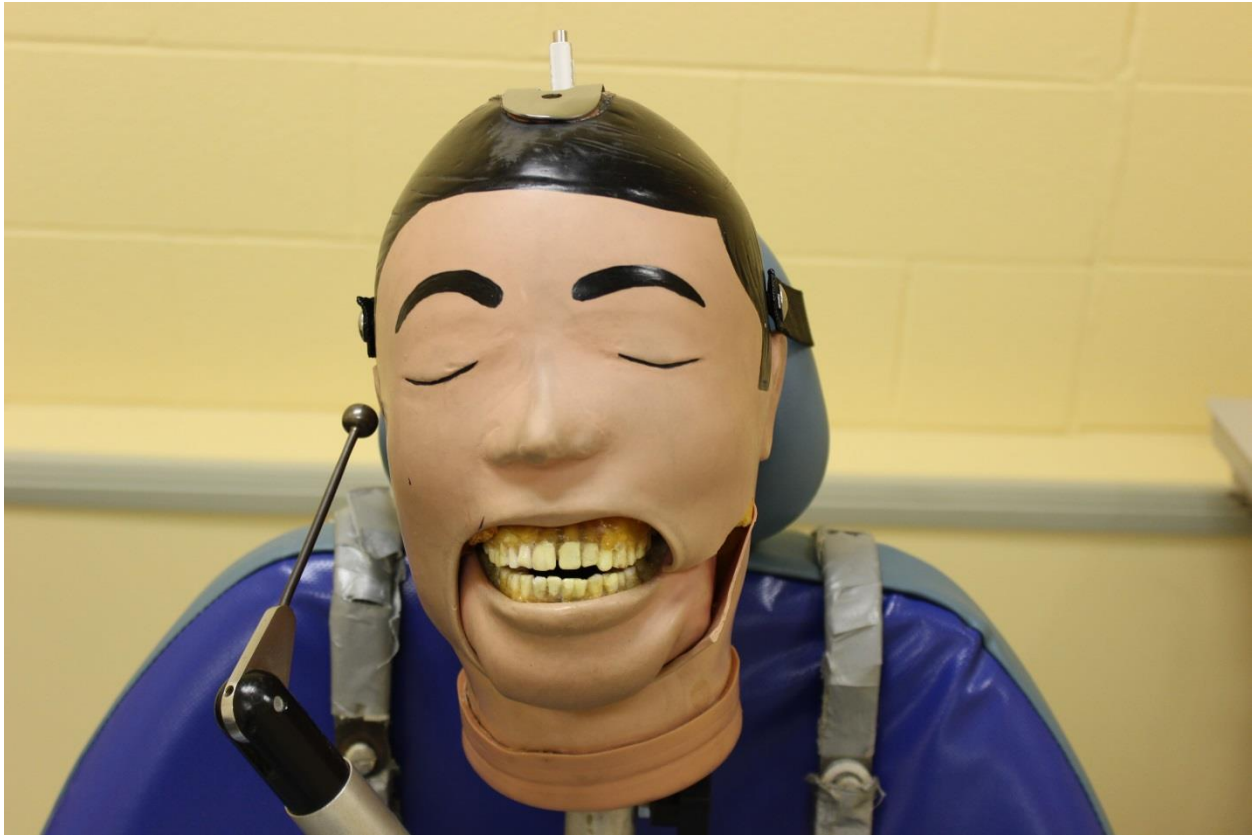


Photo 6. A human mannequin in a Durham College dental X-ray simulation laboratory which replicates real dental patient conditions (Photo by Farhan Soomro, Oshawa, ON., 2015).



Photo 7. A human mannequin in a Durham College dental hygiene simulation clinic which replicate real dental patient and various oral health conditions (e.g., dental caries) (Photo by Farhan Soomro, Oshawa ON. 2015).

Despite their documented uses in the health sciences, health educators are still skeptical and reluctant to embrace these new methods of teaching and training. Some authors (e.g., Gleason, 2015; Pauli, 2005), believe that the reason for this could be either due to time constraints or simply that no single teaching approach or method works for all. Others believe that educational gaming and simulation are not serious educational tools (Royse & Newton, 2007). Hence, health educators often prefer more traditional styles of teaching (e.g., didactic, lecture format). As a result, there remains limited information on the noted benefits and impacts of educational gaming and simulation, including their effects on knowledge building and skill acquisition, and changes in behaviour in the health sciences (Bottino, 2014; Webb et al., 2011; Papastergiou, 2009).

2.6. Aims of the Review of the Literature

This review seeks to examine the use of educational gaming and simulation as teaching tools for health education and training in the health sciences. The following questions will be explored:

- (i) Is educational gaming and simulation as teaching tools effective in health education and training in the health sciences (e.g., nursing, medicine, dentistry)
- (ii) Does educational gaming and simulation enhance long-term retention of knowledge?
- (iii) Does educational gaming and simulation promote and foster clinical confidence and/or mastery of required clinical skills?
- (iv) What is the acceptability of educational games and simulations by students in terms of preference and/or more enjoyable teaching tools over more traditional teaching methods (e.g., lectures, didactic)?

2.7 Educational Games

Traditional teaching approaches (i.e., lectures, seminars) have been shown to be effective and economical (Swiderska et al., 2013). However, they do not promote active learning environments that support critical thinking and problem solving skills; are not interactive, and often lack motivation and engagement due to their passive nature, which are essential elements of learning (Gipson & Bear, 2013). Although lectures are widely used as a method for teaching in the health sciences, they are often dull, deliver large amounts of information in short time periods, and promote passive processes of thinking, rather than active or contextually relevant learning (Shiroma, Massa & Alarcon, 2011). Moreover, several studies (e.g., Charlier & De Fraine, 2013; Boeker, Andel, Vach & Frankenschmidt, 2013) indicate that lectures are not suitable for all types of learning styles and students. Some even believe they are boring and non-stimulating due to their uninvolved nature (Shiroma et al., 2011; Swiderska et al., 2013).

Conversely, educational games are innovative teaching tools that have been shown to promote critical thinking, enhance clinical confidence building and promote problem solving skills (Anyanwu, 2014). Their acceptance for a wide variety of situations (i.e., academics, music, and arts) and capacity to accommodate different learning styles (e.g., interactive, group demonstration/activities, technology-based learning) have made them a popular choice for students and progressively minded instructors.

In the health sciences, their use is particularly noted in teaching and training physicians, nurses, dentists, and other health care professionals (e.g., respiratory technologists, occupational and physical therapists). Here, their use is particularly useful in teaching large and complex texts (e.g., books, manuals), reinforcing concepts (e.g., anatomy, microbiology, and pharmacology), and

improving retention (e.g., memorize names of human body parts/ structures). For these reasons, a wide variety of games have been employed as teaching tools (e.g., Jeopardy-type games, quizzes and puzzles) in diverse settings (e.g., classrooms, laboratories, online). For example, board games (e.g., chess) can be played to educate about tactics and high-risk clinical decision-making skills (e.g., emergency situations such as a patient arresting), a card game (e.g., DNA Re-EvolutionN) to teach molecular chemistry, and a “Jeopardy-type” game to improve knowledge and promote teamwork (Khan et al., 2012). Although similar in outcomes and objectives (e.g., educational), their applications often differ. For example, some seek to solve a problem, to learn a new skill and/or to access technical materials. Some games and simulators are technically inclined (e.g., computer-based games, electronic games, video games), others may be complex in nature (e.g., serious games), while some may involve group interactions (e.g. multiplayer, group/team quiz competition). Regardless of their content, their purpose in education remains the same: To improve, foster, and motivate the students’ knowledge base, clinical skills, attitudes and desired behaviours as health care professionals in training.

On the contrary, some studies report negative aspects of gaming such as harmful effects on eyes (e.g., dry eye disease, redness, and irritation), strain due to repetitive motion, and personal changes (e.g., aggressive, hitting) (Conolly et al., 2012; Blakely, 2008). In addition, games can be costly because they often require technology (e.g., hardware, software, and Information technology services), space, time, and funding. Table 1 below summarizes some of the major strengths and limitations.

Table: 1. Major strengths and limitations of educational games.

Strengths	Limitations
<ul style="list-style-type: none"> • Rules provide structure for learning and context • Promotes active learning through interaction • Creates conducive learning environment • Competitive nature increases interest and motivation to do well • Enhances short-term and long-term knowledge retention • Evaluates and assesses learning processes on ongoing basis • Promotes teamwork and group critical thinking and problem solving skills • Facilitates social and emotional through group interaction • Displays new information creativity • Motivational • Challenging and fun 	<ul style="list-style-type: none"> • Game-based learning style may not be suitable for all students and learning styles • Require some technical competency to play/operate the game hardware/equipment • Creates stress when incorrect answers are given • Competition can be viewed as a threat • Persistent high cognitive demand may be a challenge • Time consuming activity/may take time to setup, arrange and/or load • Previous game experience may be required for successful interaction experience • Support of technology and infrastructure may be required • Age-restrictions to meet different growth and development levels and needs

Table: 1. continue...

Strengths	Limitations
<ul style="list-style-type: none">• Provides immediate feedback mechanisms• Enhances problem solving skills• Builds self-confidence	<ul style="list-style-type: none">• Game may be costly to purchase (e.g., software, hardware, information technology services)

2.8 Educational Games and Health Sciences

A total of fourteen studies were identified from the searches conducted which examined the effect of educational games on students' knowledge, skills, retention, and confidence (e.g., Abdulmajed, Park & Tekian, 2015; Akl, Pretorius, Sackett, Erdely, Bhoopathi, Alfarah & Schunemann 2010; Anyanwu, 2014; Gipson, 2013; Hannig, Kuth, Ozman, Jonas, & Spreckelsen 2012; Jirasevijinda & Brown, 2010; Khan, Telemesani & Alkhotani, Elzouki, Edrees & Alsulimani, 2011; Miralles, Moran, Dopico & Garcia-Vazquez 2013; Rondon, Sassi & de Andrade 2013; Schuh, Burdette, Schultz & Silver 2008; Selby, Walker & Diwakar 2007; Shiroma, Massa & Alarcon, 2011; Swiderska, Thomason, Hart & Shaw 2013; Webb, Simpson, Denson & Duthie 2012). Table 2 shows the characteristics of the studies for the key search terms educational game and educational gaming.

Of the fourteen aforementioned studies, eight studies examined the positive effects of educational gaming on students' knowledge, skills and retention (e.g., Abdulmajed, et al., 2015; Anyanwu, 2014; Hannig et al., 2012; Jirasevijinda, 2010; Miralles et al., 2013; Schuh et al., 2008; Swiderska, et al., 2013 & Webb et al., 2012). Three studies reported that both educational gaming and traditional lecture formats were equally effective (e.g., Khan et al., 2011; Rondon et al., 2013; Shiroma et al., 2011). Two studies found that the traditional lecture approach appeared to be more effective in knowledge retention than gaming (e.g., Gipson, 2013; Selby et al., 2007), and one study was inconclusive as to which method was more effective (e.g., Akl et al., 2010). In general, most studies found that gaming was perceived as motivational, interesting and more enjoyable teaching tools than conventional lectures. However, these studies are subject to high risk of biases either due to a small sample size (i.e., low power), lack of randomization and/or control, methods of collection of data, lack of description of sample characteristics (i.e., sampling bias), self-

reported survey (i.e., recall bias, nonresponse bias). Taken together, their generalizability may be questioned. These limitations will be further discussed below.

2.9 Educational Gaming and Knowledge and Skill Acquisition

Anyanwu (2014) studied the effects of a board game teaching method called “Anatomy Adventure” on 95 second-year medical and dental students. The aim of the game was to teach gross anatomy of the upper limb; while reducing some of the negative factors associated with learning anatomy including fear, stress, and lack of interest (Anyanwu, 2014). To make comparisons between educational gaming versus traditional lecture formats, students were randomly assigned into two groups (i.e., game group n=50 and non-game group n= 45).

This multiplayer game was played on a board with die, tiled stacks of question cards and dummy/false money bills. To make the learning stimulating and interesting, the board was divided into four major travel routes that were named after anatomical structures such as *Vascular Street*, *The Osteology and Muscular Avenue*, *Nerve Lane* and *General Road*. The rest of the game rules appear similar to the commercially available money game called “Monopoly” (photo 4a). The player moves along the streets based on the outcome of the die rolled for each turn. To create excitement, there were grants and question spots spread throughout the game. In this way, players were allowed to move through the game while answering questions and getting rewarded until they reached the finish line. This feature of the game was built to teach participants to be in control of their learning environment and speed.

Moreover, a total of 450 anatomy questions were developed to use with this game, and participants were allowed to play for a total of 10 consecutive days. A pre-test (baseline) examination was given before the game was played to both groups, and a post-test was conducted

on the eleventh day. A 20-item questionnaire rated on a three-point Likert scale was given to the game group to access their perceptions and opinions about the game. Statistical test chi-square and Fisher's exact test were employed, however, no statistical test was provided. Study reported that post-test knowledge score gains in the game group were significantly higher than their pre-test knowledge scores ($p < 0.05$). Moreover, the mean post-test score in the game group was significantly higher than the mean post-test score in the non-game group ($p < 0.05$).

In addition, more than eighty-eight percent of the participants reported that the game was very informative and should be adopted as a teaching tool at their medical school. Overall, study participants found the game useful to learn concepts regarding the anatomy. In an after-game feedback, sixty-eight point nine percent of participants found that the fear of studying and revising anatomy was reduced. Seventy-one point one percent found it interesting, and ninety-one point one percent reported improved confidence and knowledge regarding anatomy.

Similar findings were reported by Swiderska, Thomason, Hart & Shaw (2013) who examined the effects of the board game "Neonatology" on 31 undergraduate medical students. They compared the effects of two different formats (game versus traditional lecture format) on a total of 67 medical students randomized in 4 clusters with nine students ($n=9$) in each group. The intervention group consisted of 31 students who played the game, while the control group consisted of 36 students who received traditional lectures only regarding neonatology. The game group was further divided into four teams who each had to roll a dice to move along the board and to answer quiz questions based on their established neonatology syllabus. In addition, there were summary cards available to help them answer the questions, which dealt with various neonatology conditions. In the end, student's knowledge were assessed using a written examination consisting of 50 true or false questions. Subjects who played the game (intervention group) scored 4.15 points

higher (95% CI-0.8-9.17) in neonatology knowledge than the control group. Although this difference was not statistically significant ($p < 0.09$), researcher argued that it was of practical importance given that students who attained higher scores were from the interventional (game) group. However, for the students who scored lower in the intervention group, researchers believed that it could be that they were not motivated or engaged by the game. This may have resulted in their low neonatology knowledge scores. Overall, the researcher reported that the students liked the game and thought it was useful, fun, and an interesting activity.

Abdulmajed, Park & Tekian, (2015) found that there was an increase in knowledge and retention when an educational game was introduced as a teaching tool. They identified five specific studies ($n=5$) in their systematic review; which examined the effects of educational gaming interventions on various student learning outcomes including knowledge, skill, attitudes, and satisfaction. These games will be further discussed in detail below.

Beylefeld and Struwig, (2007) found that 93% of medical students who were taught microbiology through a board game called “Med Micro Fun with Facts”(MMFWF) had retained knowledge and 90% reported it was a fun activity in a post-game survey. The game covered the following seven categories: (i) Bacteriology; (ii) virology; (iii) mycology; (iv) parasitology; (v) the laboratory; (vi) clinical diagnosis, and (vii) general medicine. The game consisted of coloured triangles and spaces to represent seven subject categories. It was played with tokens (sticks), reward tokens (doughnuts), and a hundred question and answer cards with visual material/graphics on the back side of each card. To assess the learning outcomes, a mixed method approach was used including two surveys, a focus group interview, direct observation and the nominal group technique. However, only the data from the surveys and direct observation were reported in this study.

Cowen and Tesh, (2002) examined the effects of a combined game and lecture format teaching tool on nursing students' knowledge regarding pediatric cardiovascular dysfunction. They compared two groups of students comprised of a game and lecture group (treatment) and a lecture only group (control). Although no significant difference was shown in pre-test and post-test scores between the two groups, students who attended both game and lectures had better overall knowledge (94% percent correct answers), compared to students who attended lectures only (84% correct answers).

Similar findings were reported by Graham and Richardson's (2008), who designed a game called "BARNGA" to create cultural awareness in nursing students. The game consisted of cards and tables. Students moved from one table (culture) to another table (culture) and attempted to answer questions regarding different cultures. They found that the game had stimulated strong emotions which increased students' self-awareness and insights into different cultures.

Ogershok and Cottrell (2004) employed a board game to teach pediatric medicine to 37 medical students and 12 residents. The board game had one hundred spaces, which represented four equal levels of colour-coded play (i.e., basic, intermediate, advanced; and supreme). Students moved through these spaces by answering questions regarding pediatric content which was followed by a post-game evaluation survey on the students' experience. The authors reported that all game participants perceived the game as a useful and valuable educational tool. Lastly, Shah et al., (2010) reported an increase in students' knowledge scores (i.e., 85% in 2009); in comparison to the previous year average scores (82% in 2008), after students played a crossword puzzle for three lectures to learn about pharmacology and medicinal chemistry.

Miralles, Moran, Dopico and Garcia-Vazquez (2013) reported that students obtained higher knowledge scores after playing the molecular evolution game 'DNA Re-Evolution'. This

game consisted of: (i) A board painted on a large card or paper; (ii) dough modeled as DNA and mRNA strands; (iii) clay and/or plasticine; (iv) four coloured balls that represented nitrogen bases (e.g., blue is cytosine, red is thiamine, yellow is guanine, and green is adenine); (v) dice and prawns; (vi) cardboard cards that represented actions or event that will affect the molecules in the chain; (vii) coloured markers/pencils, and (viii) toothpicks were the chemical bonds where nitrogen bases will be attached.

The game could be played individually or in small groups as teams. Here, the task was to transcribe a DNA chain into mRNA and construct a mRNA chain. The game was played by two groups of students, one with a subject major in science ($n=12$), in comparison to non- science majors ($n=24$). Students from both major and non-science major groups reported higher knowledge gains after playing the game (paired t-test = 3.20 and 7.34), and the results were statistically significant ($p < 0.0047$, and $p = 0.0001$, respectively). Moreover, students found the game very interesting and scored the game as 8.9 when 0 = not interesting at all, and 10 = very interesting and formative. A total 78% of who played the game students reported that it was a useful and fun classroom learning activity.

Schuh, Burdette, Schultz and Silver (2008) examined the effects of a quiz-type game on 17 postgraduate medical students' knowledge within a neurosciences department at a local hospital. They compared a game intervention with another group of 20 postgraduate students (control) who had previously attended the lectures only for the same subject. The investigation utilized the Residency Inservice Training Examination (RITE) assessment scores for determining students' knowledge in their medical residency program. They found that the RITE knowledge scores were higher in the game group (63.6 ± 4.12), when compared to the lecture only group (49.4 ± 2.35). The results were also found to be statistically significant ($p = 0.002$).

By contrast, Gipson and Bear (2013) found that the traditional lecture format was superior for increasing nursing student's comprehension and application of knowledge regarding the renal system, in comparison to a board game only. The lecture consisted of Power Point slides, handouts, and assigned readings on the renal system. The game group played a "Renal Nephron Game Board", which consisted of a board that represented a nephron, game pieces, and a 120 multiple-choice, true/false, fill-in-the-blanks, and open ended questions. Students' who attended the lecture (n=51) scored higher (mean, 81.95 [SD, 7.37]) than the students (n=53) who played the board game only (mean, 81.47 [SD, 6.43]) on a 100-point examination. However, this difference was not statistically significant. In addition, both the groups reported that they were equally satisfied with the teaching methods employed to learn about the renal system.

Similarly, Selby, Walker and Diwakar (2007) found that an interactive lecture format had significant positive effects on student's short-term knowledge, when compared to a game format. They employed the game "Developmental Charade" to teach child development to one hundred students during their obstetrics, gynaecology and paediatrics rotation. The game consisted of cards which described milestones and behaviours for key developmental ages. The students were asked to pick a role-play character (i.e., mother or the child), and act out the condition/behaviour based on the milestone from the card. The remaining students in the group were required to ascertain the age of the child based on these improvises. The control group was taught the same topic using a traditional lecture only format. The students were assessed for their short-term and long-term knowledge retention and performance in paediatrics using a multiple choice questionnaire and Objective Structured Clinical Exam (OSCE). Students from the interactive lecture (group A) scored significantly higher (mean score in quiz after teaching =43.6%; 95% CI; [17-70]) on the quiz, in comparison to group B controls (mean score in quiz after the session =37.15%; CI 95%;

(11-63)). This difference was found to be statistically significant ($p < 0.01$). No significant differences were noted in OSCE performance scores. Although female participants were higher for the lecture group (68.7%) when compared to the game group (55.7%), this difference was attributed to the relative distraction of students during game sessions.

Lastly, Akl, Pretorius, Sackett, Erdley, Bhoopathi, Alfarah, Schunemann, (2010), suggested that the use of educational games as an instructional method and their effects on learning outcomes should be further examined. They conducted a systematic review of the literature to systematically review the effect of educational games on medical students' knowledge, satisfaction, skills, attitude, and behaviour. Their search identified five randomized control trial (RCTs). Of the five studies identified, only three reported positive effects of educational games on medical students' knowledge (e.g., Boreham et al., 1989; Selby et al., 2007; Siqueira, 1992). The remaining two studies (e.g., O'Leary et al., 2005; Udin and Kuster, 1985) found no statistically significant difference in knowledge or attitude scores after the intervention.

2.10. Jeopardy-Type Games and Health Education

Jirasevijinda and Brown (2010) employed the game "Bronx Jeopardy" to teach psychosocial aspects of theory to 34 pediatric residents during their academic year. The game was based on a popular television game show "Jeopardy", and consisted of five different question categories projected as Power Point slides. There were three contestants who represented three teams. Each team had 15 seconds to discuss and provide an answer to a question. Penalties were included for incorrect answers. A survey was conducted after the training session was complete to rate the content and format using Likert-type scale. Survey responses were dichotomized into "agreed" and "not agreed", where 4 and above was agreed. Eighty-eight percent participants completed self-reported survey and all (100%) reported that the game was an effective and fun

way to learn information about various paediatric psychosocial theories, stimulated their interest in learning about their community, and helped them in retaining information they had learned. About ninety-six point six percent respondents reported that they agreed that the game encouraged them to learn more about their community, interact with their fellow members, and increased their awareness about the challenges faced by their community.

Webb, Simpson, Denson & Duthie (2012) reported on the effects of a Jeopardy-type game on eight postgraduate students' short-term and long-term knowledge and satisfaction. The game was based on the popular Television game show "Jeopardy". Here, participants were provided clues in the form of an answer, and they were required to answer them in the form of a question. They were penalized for giving incorrect answers. There were two rounds of five categories related to various geriatrics topics with five questions per category, respectively. Participants' geriatrics and non-geriatrics knowledge was assessed using a paper-based pretest and post-test examination. These researchers found that there was a significant difference between pretest knowledge scores (51.5% [SD, 13.6]) and post-test knowledge scores (82.6% [SD, 9.7]) for the participants. The results were also found to be statistically significant ($p=0.027$). Moreover, participants also reported that they were highly satisfied with the gaming session and reported an overall rating of 4.6 (SD, 0.5) on a scale of 1 = not reported to 5 = outstanding.

Khan, Telemesani, Alkhotani, Elzouki, Edrees & Alsulimani (2011) examined the effects of two different teaching formats (Jeopardy-type versus traditional lecture only) on knowledge and retention for 82 fifth-year medical students during their pediatric rotations. They found that both the Jeopardy-type game and traditional lecture format methodologies were equally effective in improving students' paediatrics knowledge (game format mean pretest = 10.9; mean post-test I = 18 and lecture format mean pretest = 10.2; mean post-test I = 17.7). However, the students from

the game group also showed improved retention of knowledge, in comparison to the lecture-only group based on post-test results administered two months later (CI: -3.447-0.455; t : 2.5, $p < 0.01$). Moreover, the students found the game format enjoyable and described it as a fun activity which improved class engagement. They also reported that the game was their preferred method of learning the pediatric content.

Shiroma, Massa & Alarcon, (2011) compared the effects of Jeopardy-type game versus a traditional lecture format teaching on forty-three third-year medical students' acquisition of knowledge in psychopharmacology during a 6 week clinical psychiatry rotation. The students in the game group ($n=43$) were divided into two competing teams; whereas students in the lecture group ($n=14$) received identical content which was delivered via a lecture. Students from both the groups were assessed for their knowledge of psychopharmacology using a randomized pre-test-post-test experimental method. A 20-item multiple choice questionnaires was employed to conduct this assessment. At the end, a student satisfaction survey was also conducted to assess their perception of difficulty, interest, enjoyment, and improvement of psychopharmacological knowledge in a Likert-type scale (e.g., response categories: 1=lowest; 5= highest). In summary, students from both the groups (i.e., game and traditional lecture group) reported improved knowledge scores related to psychotropic drugs [(game group $t= 10.86$, $p < 0.001$; control $t= 4.82$, $p < 0.001$]. However, the researchers found no statistically significant differences between the two methods of teaching for improving student's knowledge. Nonetheless, students found that the game approach was more interesting and satisfying than lectures. Taken together, these studies suggest that educational games (i.e., Jeopardy-type games, board games) can be effective in improving students' knowledge, retention and confidence related to the education and training of various students in the health sciences.

2.11. Serious and Computer-Based Games and Health Education

Hannig, Kuth, Ozman, Jonas, & Spreckelsen (2012) investigated the effects of a computer-based serious game called “eMedOffice” on 41 medical students’ conceptual knowledge regarding future clinical practice and problem-solving skills. The game consisted of the software package “eMedOffice” and required hardware (i.e., computer) to connect to the game server using a standard web browser. Upon connection, participants were required to learn how to react to different learning scenarios including: (i) Furnishing medical practice/rooms; (ii) how to arrange furniture and technical components of a practice, and (iii) how to interact with simulated patients and/or staff to solve problems. The game was introduced during the sixth year of a medical training curriculum as an elective, which was played in a computer laboratory. The authors employed a 22-item scale and a self-reported seven-item questionnaire (two per participant) to assess their learning outcomes of the game. The students rated the game 4.07 points (i.e., 5=best; 1=worst), which suggests that students liked the game and found it to be useful in terms of practice setting requirements and setup. Moreover, medical students also reported that the use of serious game increased students’ knowledge base regarding practice, which was evident from the statistically significant differences between pre-test-post-test knowledge score results ($p < 0.001$). In addition, these students also reported positive aspects of gaming in terms of motivation, excitement, and fun during the session. This fostered valuable discussions and competitive collaboration among them.

By contrast, Rondon, Sassi & de Andrade (2013) found that a computer game-based learning method (CGBLM) was comparable to a traditional lecture method (TLM) in terms of improving second year medical students’ short-term knowledge retention regarding head and neck anatomy and physiology. The game consisted of interactive learning software called “Anatesse 2.0” which contained animations, assigned readings, chapter support, and self-study quizzes

related to the bones and muscles of the head, face, and neck. The software was designed to aid learning and understanding of anatomy and physiology of speech, language, hearing and swallowing systems. The material was provided in a CD-ROM which was played through a computer notebook connected to a multi-media projector. Students in the lecture group received this information in the form of their scientific text book. The authors assessed students' knowledge, and short-term and long-term knowledge using a 50 multiple choice questionnaire, which was assessed during three different times (i.e., pretest, post-test, and long-term post-test). They found both methods were equally effective in short-term knowledge gains ($p=0.176$). The students who experienced TLM ($n=14$) reported better long-term knowledge retention and also had higher physiology post-test knowledge scores, when compared with pretest scores ($p=0.019$). However, students who experienced CGBLM ($n=15$) reported better anatomy scores in the comparison between pretest and post-test ($p=0.042$). Moreover, the investigators found no statistically significant differences between students' total knowledge scores in both groups for the post-test and long-term post-test (group I, $p=0.111$; group II, $p>0.999$). Overall, the authors concluded that the lecture format was more effective in improving students' long-term knowledge retention. This is an important outcome because long-term retention and application of knowledge is desirable when designing health-related clinical curriculum to train various health care professionals.

2.12. Simulation in the Health Sciences

Simulation aims to imitate or replicate real-life situations/scenarios to practice and/or master various clinical skills in a safe and secure environment (Cant & Cooper, 2009). Many studies associate the use of simulation with science fiction, futuristic businesses, and computerized gaming systems. Few studies to date have associated this technology with health (e.g., Bottino et al., 2014; Garriss & Ahler). The use of simulation for skills validation dates back to late 1920s when

the first flight-training simulator was introduced to train student pilots (Bland et al, 2010). Subsequently, there use has been expanded to other areas (e.g., business, forensic, law enforcements, military applications, and education) (Friedl & O'Neil, 2013; Gaba, 2001).

The literature indicates that the use of these types of tools for teaching promotes active learning, helps to foster critical thinking, and problem solving, while promoting a learning environment comprised of excitement and fun (Royse & Newton, 2007). On the contrary, some studies report negative effects of playing simulation type of games such as aggression and decreased attention spans (e.g., Gleason, 2015; Graafland, 2012). Table 3 below provides the reader with a summary of the major strengths and limitations described in the empirical literature.

Table: 2. Major strengths and limitations of simulations

Strengths	Limitations
<ul style="list-style-type: none"> • Helps to foster critical thinking • Simulations are highly interactive • Enhances self-confidence • Visually appealing • Promotes role playing as health professionals • Live environment simulates real world scenarios which helps students to understand and apply knowledge in a safe and secure environment • Scenarios of clinical case studies can be easily replicated to assess gains in knowledge or clinical skills • Encourages critical thinking skills • Easy demonstration through models • Promotes logical thinking and problem-solving within a clinical or practice context • Fosters reasoning ability • Provides immediate feedback of positive and negative clinical outcomes in a safe and controlled setting. 	<ul style="list-style-type: none"> • May require special training by an instructor or student • Hardware and/or software may be required and increase associated information technology (IT) costs • Technological competencies may be required to setup/operate the software/hardware • Cannot replicate all clinical scenarios which are often multi-faceted • Cannot account for multiple clinical complications (e.g., patient with history of heart disease, diabetes or cancer) • Modeling can be costly and time consuming • Competencies in technology required • Results may involve statistical analysis and ability to comprehend results obtained • Use of hardware/software requires challenge. • Update /calibration of equipment is often required • Repetition in application may be required. • Could be expensive (to cover the cost of simulator, computer and other equipment, and IT personnel to setup/manage software/hardware systems

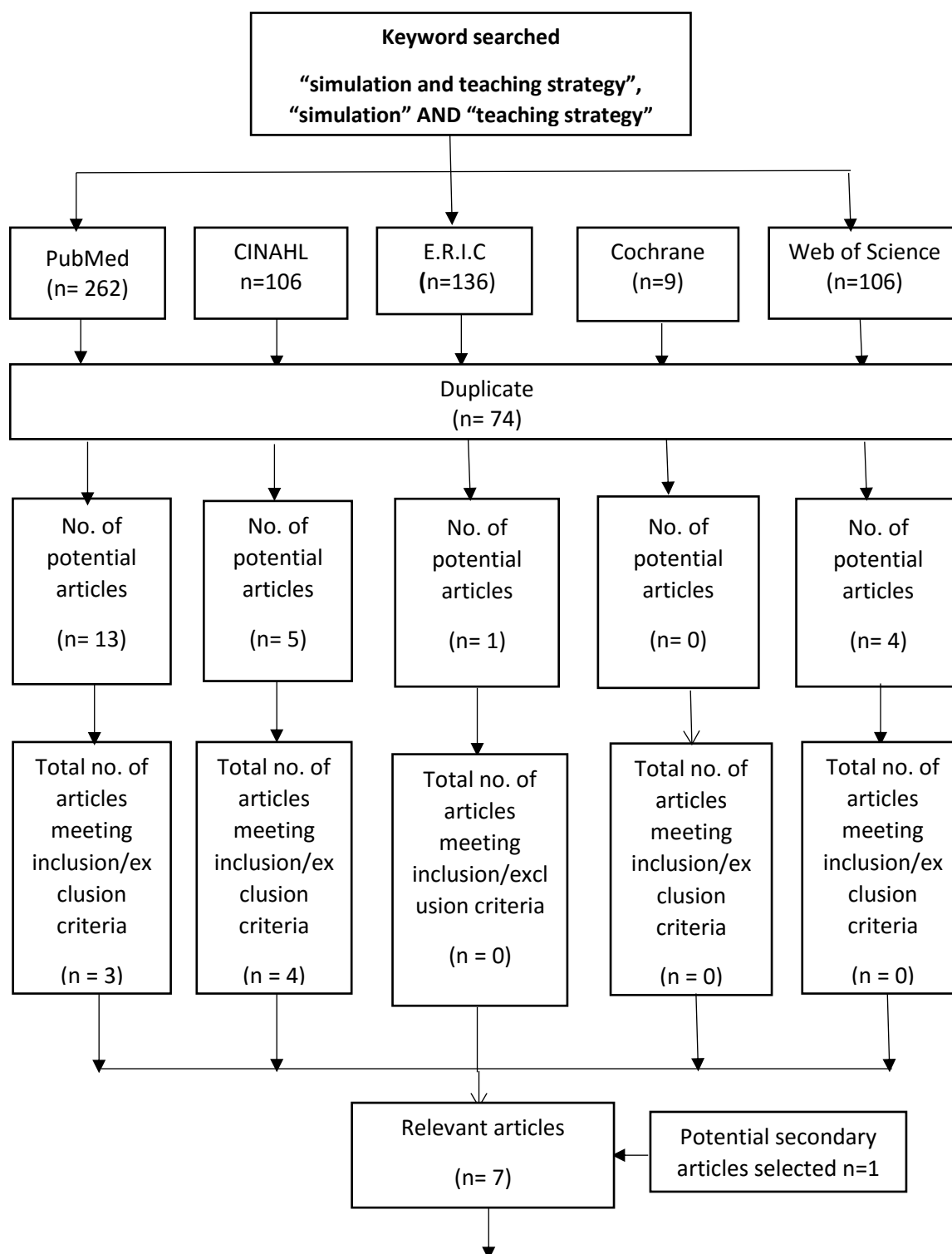
Recently, simulation has been found to be widely employed in the health sciences to train student nurses, physicians, and dentists (Cant et al., 2009). Simulations can assist the user to interact in a safe and controlled environment with the use of a simulator (e.g., mannequin), while applying their knowledge and/or skill to a clinical context or situation. For example, their use as an assessment tool to validate nursing students' performance in clinical/practice examinations has been well documented for Objective Structured Clinical Examination (OSCEs) (Bartfay, Rombough, Howse, & Leblanc, 2004).

Like a game, simulations are also interactive in nature. In fact, they are often more interactive than games since they require active participation from all users (e.g., role play, case studies) to facilitate learning and/or master clinical skills (Sinclair & Fergusson, 2009). However, they differ from games in that they lack the competition and challenge component.

2.13. Simulation as a Teaching Tool:

A total of eight studies were identified, which examined the effect of simulation on knowledge, skills, critical thinking abilities, and confidence (see flow chart 2 below) (e.g., Beyer et al., 2012; Cant et al., 2009; Cooper et al., 2011; Gibbs et al., 2014; Lancaster, 2014; Sinclair, 2009; Tawalbeh et al., 2014; Tiffen, 2009).

Flowchart: 2. Primary search strategy for key search term “simulation and teaching strategy”



Of the eight studies, all but one (e.g., Gibbs et al., 2014) reported positive effects of simulation on knowledge/skills and confidence (e.g., Beyer et al., 2012; Cant et al., 2009; Cooper et al., 2011; Lancaster, 2014; Sinclair, 2009, Tawalbeh et al., 2014; Tiffen, 2009). The study by Gibbs et al., (2014) found that the case study group performed better on post-test scores, in comparison to the simulation group. These studies will be critically examined below. Table 4 below shows the characteristics of the studies for key search term simulation and teaching strategy, and simulation AND teaching strategy.

2.14. Simulation and Knowledge and Skill Acquisition

Cant and Cooper (2010) reported on the effects of simulation on nursing students' knowledge and critical thinking skills. They completed a systematic review of 12 published studies on simulation, which described the effectiveness of simulation for clinical training. They found that the students who attended simulation sessions had improved knowledge, critical thinking skills, and enhanced satisfaction and/or confidence, in comparison to students who only attended traditional lectures. Lastly, medium and/or high fidelity simulation techniques using mannequins were found to be most effective when used for teaching clinical techniques and applications.

Cooper, Cantt, Porter, Bogossian, McKenna, Brady and For-Young (2012) found that simulation had positive effects on midwifery students' learning outcomes, when compared to traditional lectures only (i.e., didactic format). They identified 24 studies in their systematic review that explored the use of simulation on midwifery education. Collectively, these studies showed the positive effects of simulation-based midwifery training on students' knowledge, skills and time management skills.

Lancaster (2014) examined the effects of a serious game (SG) simulation on third-year nursing student's knowledge, self-confidence and satisfaction, problem-solving skills, feedback, and support or realism. Significant increases in knowledge scores were noted based on pre-simulation to post-simulation tests and the results were statistically significant [$t(78) = -2.651$; $p < 0.01$]. Students also reported high levels of satisfaction and increased confidence as a result of this teaching tool.

Tawalbeh and Tubaishat (2014) examined the effects of simulation on 82 nursing students' knowledge acquisition and retention regarding Advanced Cardiac Life Support (ACLS) training. The experimental group ($n=40$) received a simulation scenario relating to ACLS, a 4-hour PowerPoint™ presentation and a demonstration on a static mannequin. The control group ($n=42$) only received the presentation and a demonstration on a static mannequin. Based on the findings from this randomized controlled pre-test-post-test design experiment, the researchers found that students who participated in the simulation session had higher knowledge scores, confidence and retention of knowledge and theory, in comparison to control group ($p < 0.001$).

Tiffen, Graf, Corbridge (2009) studied the use of human patient simulators in 18 advance practice nursing students' (experimental group) confidence building related to heart and lung assessments. In comparison, control group ($n = 14$) received one-hour of standard course lecture and laboratory material. Students were assessed using a post-simulation/teaching session. The investigators found that the nursing students who attended the simulation session had better knowledge and confidence scores [$F(6, 25) = 7.544$, $p < 0.001$], when compared to controls.

Gibbs and Deborah (2014) conducted a comparative analysis of a human patient simulation (HPS) versus a case study (educational intervention). They examined nursing students' learning outcomes (e.g., critical thinking abilities) and perspectives related to diabetes education. Sample

size was not reported. An experimental, two-group pre-test and post-test was employed by the investigators. Students were randomly assigned to either HPS scenario or the case study. The scenarios were based on patients experiencing hypoglycemia. Student in the case study group received a three-hour Power Point presentation, and a 30-minute video related to diabetes management. Students in the simulation group were divided in five groups who performed role playing as a primary nurse, secondary nurse, medication nurse, documentation nurse, and patient's spouse. The pretest consisted of 10 question related to normal fasting, normal and abnormal blood glucose levels, clinical sign and symptoms of hypoglycemia, and nursing interventions for treating hypoglycemia. These questions consisted of nine multiple-choice questions and they were also identical for post-test measures, which were administered immediately after the educational sessions. These researchers found that students from the case study group had higher post-tests scores (e.g., 80%), when compared to the simulation group (68%, $p=0.04$). However, on the clinical evaluation tool, the simulation group scored higher (17 from 22 points), in comparison to the case study group (8, $p<0.001$). Notably, all students reported that they either agreed or strongly agreed that simulation was an effective teaching tool for learning about the clinical manifestations and nursing management of hypoglycemia ($p < 0.03$).

Beyer (2012) examined the effectiveness of a human patient simulation (HPS) for classroom settings. A pretest-post-test experimental design study was employed to assess knowledge gains in 45 nursing students. The pretest-post-test questionnaire consisted of 10 multiple choice questions related to the analysis and application of theory and patient care. In addition, a second 18 question survey was conducted to measure students' attitudes and perceptions of simulation class activity. The students were exposed to a simulation scenario after reading the assigned material. All the students' were given patient medical records related to the

scenario. The students were able to view blood pressures, respiratory rates, and electrocardiogram wave forms on a large video display monitor, which replicated a realistic patient's room in a hospital. After the simulation, there was a debriefing session. The researchers found that there was a significant difference between the mean number of correct responses obtained on pretest scores (5.40, SD =1.84), compared to the mean number of correct responses obtained on post-test scores (6.51, SD=1.56). This indicates that the simulation had positive effects on student learning outcomes [$r(44) = 4.2, p = 0.0001$]. Moreover, the student survey revealed a score of 4.18 (1= strongly disagree, 5= strongly agree) for the simulation experiences, which indicates that they found the nursing students' HPS experience valuable and effective.

Sinclair and Ferguson (2009) conducted a comparative analysis of simulated learning activities for nursing students. This mixed method study had a sample size of 250 second-year collaborative baccalaureate nursing students ($n=250$). The control ($n=125$) group received lectures on adult health, mental health and child health. The intervention group ($n=125$) received lectures in addition to various simulation scenarios. The researchers employed mid-fidelity mannequins and role-playing for the simulation group. All students were also required to complete a brief demographic questionnaire.

The investigators utilized a modified Baccalaureate Nursing Student Teaching-Learning Self-Efficacy Questionnaire to assess changes on pretest and post-test scores. These questionnaires were analyzed using paired t-tests. There were significant differences on pre-test versus post-test knowledge scores for the intervention group in all categories except one (e.g., mental health $p<0.218$). A description of this exception was not provided in the study and no confidence interval was reported either. The results for the other four categories, however, were found to be statistically significant (i.e., post-operative $p<0.002$; child with URI $p<0.033$; client with hip

replacement $P < 0.031$; and client with CHF $p < 0.001$ respectively). Moreover, 91% of combined (i.e., lecture and simulation) learning activities were reported to be highly effective, and students were found to be satisfied with the learning experience, as compared with only 70% from controls. Taken together, use of simulation as a teaching tool had significant positive effects on nursing students' learning outcomes including knowledge, skills, satisfaction and confidence building.

SECTION 3

Discussion

3. Discussion

There is a growing body of evidence to suggest that educational gaming and simulation may be beneficial as teaching tools in a range of health sciences education and training (e.g., medicine, nursing, and dentistry) (e.g., Anyanwu, 2013; Beyer et al., 2012; Cantt et al., 2009; Jirasevijinda et al., 2010; Lancaster, 2014; Schuh et al., 2008; Sinclair, 2009; Shiroma et al., 2011; Swiderska et al., 2013; Tawalbeh et al., 2014; Tiffen et al., 2009; Webb et al., 2012). The majority of studies, however, were conducted in United States, United Kingdom, Australia, Germany, Spain and other parts of the world (Gipson, 2013; Miralles et al., 2013; Rondon et al., 2013; Selby et al., 2007; Webb et al., 2012). Comparatively, only one study was conducted in Canada (e.g., Sinclair, 2009). A study by Bartfay and Bartfay (1994) is also Canadian, however, it is outside of the 10-year-period searched for this review. The present review aims to close this gap and add to the growing body of knowledge, which suggests that educational gaming and simulation appears to be effective teaching tools in comparison to traditional lectures.

This review identified 1595 potential peer-reviewed publications that indicate that the interest in the use of educational gaming and simulation as teaching tools has increased during the past decade. Upon critically examining the studies selected for this review, the overall results show significant positive effects of educational gaming and simulation related to students' knowledge, skills, retention, satisfaction and confidence building (Abdulmajed et al., 2015; Schuh et al., 2008). It was also noted that the impact of educational gaming and simulation on student's learning outcomes varied from one study to another. This could be attributed to: (i) the time duration that the game was played (i.e., some game sessions were longer than others) (Tiffen et al., 2009); (ii) study population (i.e., students with previous game play experiences versus students with no previous and/or first game experience) (Khan et al., 2012), and/or (iii) methodology employed

(i.e., absence of controls, power of the study was not reported and/or questioned, or small sample size employed) (Rondon et al., 2013).

Moreover, studies selected tended to use experimental pretest-post-test study design with or without satisfaction surveys. Majority of studies had small sample size and the subjects were from first and second-year undergraduate students. Notably, none of the studies reported pretest sensitization, and/or employed a repeated measure or crossover design. Due to lack of randomization in some experimental and quasi-experimental studies, and some lacked a control group (e.g., Anyanwu, 2014, Miralles et al., 2013; Hannig et al., 2012, Webb et al., 2012, Beyer et al., 2012. Gibbs et al., 2014, Lancaster, 2014), the internal validity of these noted studies cannot be adequately validated.

The studies reviewed varied greatly with respect to: (i) aims of the research; (ii) design and content of pedagogical approaches (i.e., educational games/simulation and lectures), (iii) methodologies employed, and (iv) instruments used to assess student's knowledge and/or mastery of the clinical skills. These educational games and simulation approaches included board and card games to teach anatomy and microbiology to medical and dental students (Anyanwu, 2014; Beylefeld and Struwig, 2007; Miralles et al., 2013; Swiderska et al. 2013); Jeopardy-type games to teach pharmacology to nursing students (Jirasevijinda et al., 2010, Webb et al., 2012), serious games to learn how to setup a medical practice and knowledge related to anatomy and physiology (Hannig et al., 2012; Rondon et al., 2013), and human patient simulators (HPS) (i.e., mannequins) to master required clinical skills (e.g., Beyer, 2012; Gibbs et al., 2014; Tiffen et al., 2009). This widespread application of educational gaming and simulation in various fields of health sciences indicates their interdisciplinary nature and potential for learning.

For example, Schuh and coworkers (2008), found that students who played a neuroscience educational game (interventional group) were found to have improved Neurology Residency Inservice Training Examination (RITE) post-test scores (63.6 ± 4.12) in comparison to students who only attended traditional lectures (controls = 49.4 ± 2.35 , $p < 0.02$). Although the study compared the interventional cohort with a historical cohort, the sample size was small ($n=37$). Playing game-show type oral quiz enabled students to remember information longer, think critically, and later on resulted in their success in residency program.

Similar findings were reported by Tiffen et al., (2009), who utilized a randomized controlled trial (RCT) study design to compare simulation-based learning with traditional lectures. The researchers found that students who attended simulation sessions (intervention group) reported higher knowledge, confidence, and skill gains, in comparison to students who only attended lectures or case studies (controls) ($p < 0.001$). Although this was a pilot study with a small sample size ($n=32$), it provides more rigorous evidence to establish a causal association between the use of educational gaming and simulation and associated positive effects on student's knowledge, skill and confidence. Here, hands-on experience with patient simulator allowed students to hone their physical/motor skills, and improve confidence while remaining focused. It was noted from the empirical evidence that both health educators and the students would like to see an increase in the use of games and simulation in health sciences (Anyanwu, (2014). The above author successfully used anatomy game to cover key anatomy concepts. Playing game allowed students to work in group which improved their team work skills, and attitude while enjoying the course material.

While there is a dearth of evidence showing positive impacts of educational gaming and simulation on knowledge, skills, and retention, a number of studies also report that playing games in classrooms stimulated students' mind and increased their confidence in mastering course

material which, in turn, led to their satisfaction in learning (Abdulmajed et al., 2015; Akl et al., 2010; Webb et al., 2012).

Several studies note the educational value of gaming and simulation, however, some studies have reported that traditional lecture format was found to be more effective than gaming or simulation (Gibbs et al., 2014; Gipson et al., 2013; Selby et al., 2007). One reason may be due to the use of a low-fidelity mannequin in simulation sessions. A high-fidelity mannequin would have been more interactive and realistic in nature, but also more expensive. Nevertheless, studies have shown that simulation appeared superior to traditional lectures because of the “hands-on” approach rather than passive learning approach (i.e., lectures) (Gibbs, et al., 2014; Gipson et al., 2013).

On the contrary, some studies reported that both teaching strategies are equally effective (Khan et al., 2012; Shiroma, et al., 2011). Although games were perceived as challenging and intimidating, students reported that learning environment during the game was fun, more enjoyable, engaging and preferred format of learning (Khan et al., 2011; Shiroma et al., 2011). This suggest increase acceptance of educational games and simulation by health sciences students.

The results of the satisfaction survey were similar among the 22 articles selected for this review; where students in the health sciences overwhelmingly reported increased satisfaction with gaming and simulation-based learning activities (Gibbs et al., 2014; Miralles et al., 2013). This upward trend in satisfaction was consistent with all types of game types (i.e., Board games, jeopardy-type games, and serious games) played by students from different levels of learning (e.g., undergraduate, post-graduate). Collectively, these findings suggests that educational gaming and

simulation offer more enjoyable and fun learning experiences that is also preferred over traditional lectures.

Conversely, only one study (e.g., Akl et al., 2010), remained inconclusive as to which method was more effective (i.e., educational gaming versus lectures). In their systematic review of RCTs, and time interrupted series studies, three studies out of five reported positive learning outcomes. Whereas, two reported no statistically significant effects on knowledge or attitude. Although they reviewed only 5 articles, they still provide a strong evidence (e.g., rank II) as the studies were either RCTs or controlled trials. These researchers concluded that further research is required to examine the effects of educational gaming and simulation. These recommendations were similar to other studies (e.g., Khan et al., 2012; Cant et al., 2009).

3.1 Limitations:

The present review has a few noted limitations. First, it was limited by the search terms employed, databases included, and time period searched (i.e., past ten years). Second, studies reviewed were mostly from the United States, United Kingdom and other parts of the world (i.e., Spain, Brazil). Only one Canadian study was found (Sinclair, 2009). Hence, the results cannot be generalized to other educational settings, especially in the Canadian context because we have a different education system.

Third, in studies where a self-reported student satisfaction survey was employed, there is the potential for: (i) Non-response bias; (ii) inaccuracies in responses (i.e., validity), and (iii) biases in self-reported data (i.e., response-style and/or memory/recall bias) (Bowling & Ebrahim, 2005). Non-response bias refers to when a survey member does not wish to participate in a survey and yet they differ in some way from those who do (respondents). The accuracy of response is when a

‘true value’ is provided, and only when validating information is present. Response-style bias refers to a respondent’s style of answering a questions according to his/her own desire, which may or may not be true. It is often known as ‘yes-saying’ to questions irrespective of their actual content. Whereas, memory or recall bias occurs when a respondent answers a question based on his/her selective memories in recalling past events and/or experiences (Bowling & Ebrahim, 2005).

Fourth, since I excluded “academic games” which focus on outcomes that are out of the scope of this review (i.e., language, math, and music/arts), there is a possibility that a potential study might have been excluded simply because the researcher(s) might have utilized the term academic games in place of educational games, especially given that the two terms have been used interchangeably.

Lastly, there was lack of definitions and/or descriptions available related to educational games and simulation in the investigations identified. Therefore, it is unclear as to what elements of the game components were used in order to replicate the findings in other settings. For example, Schuh et al., (2008) utilized a game show-type educational game which incorporated an oral quiz format; however, a description of this game-show and quiz was not provided.

3.2 Summary

Educational gaming and simulation has a long history, which dates back several decades in the health sciences. However, to my knowledge, no comprehensive review of the literature exists, which has examined the advantages and disadvantages of educational gaming and simulation as teaching tools in the past ten years. Accordingly, this review of the literature attempts to fill this noted gap. Overall, my review of the literature indicates that educational gaming and simulations have positive effects on students’ knowledge, skill, and retention.

Moreover, students' satisfaction scores on surveys also indicate that educational gaming and simulations are more enjoyable and the preferred teaching tools among the health sciences students.

SECTION 4:

Conclusion and Directions for Future Research

4. Conclusion and Directions for Future Research

There is a famous saying, “Tell me and I forget; teach me and I may remember; involve me and I will learn” – Benjamin Franklin (1706 - 1790). In conclusion, while it is evident that educational gaming and simulation do have potential benefits when employed as teaching strategies, their successful use, however, is dependent on the many factors including: (i) context in which they are applied; (ii) topic/material being taught; (iii) students’ learning objectives; (iv) different learning styles of students and their motivation to learn; (v) technological competencies of users; (vi) teaching/faculty preference; and (vii) time, and resources (e.g., hardware/software needed, information technology support). Nonetheless, gaming and simulations are sometimes viewed as ineffective, unnecessary and time consuming approaches. Hence, some educators may be reluctant to adopt them in the health sciences.

Despite these limitations, educational gaming and simulation appeared to be useful teaching tool as evaluated by the students and health educators alike. Their merit in motivating students to learn, engage, and making learning fun and more enjoyable was evident from the articles selected for this review. Notably, the most prominent theme that emerged from studies is the multidisciplinary nature and wide acceptance of educational gaming and simulation and their associated positive outcomes as evaluated by the health sciences students and health educators. The combination of play aspect, engagement through sound/ visual and/or touch, and team work added to overall successful learners’ experience. Learning in this way, educational gaming and simulation offer an innovative teaching environment that caters to the learning needs and preferences of a large audience, especially millennial students (Kaddoura, 2010).

Future research should further explore the educational benefits of educational gaming and simulation with special focus on their use as a tool for millennials. This next generation of students

are technologically savvy, great at multi-tasking, and prefer experiential learning. They also represent a large body of students who enter universities from high school. This is where educational gaming and simulation can have a powerful impact. Although, this present review does not cater to the teaching needs of one single profession and/or student body, it may be worthwhile to explore the learning objectives and challenges of these students.

Moreover, studies found in this review mostly examined outcomes such as knowledge, skills, retention. More rigorous evaluative studies (i.e. meta-analysis, randomized controlled trials) should be employed to assess outcomes such as long-term knowledge retention, behavior, attitudes, and effects on other cognitive outcomes/function (i.e., cognitive rehearsal). Taken together, further research with clear objectives and outcome measures along with reliable and credible assessment instruments are needed to inform educators of the true benefits of educational gaming and simulation for the purpose of improving teaching and learning.

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APPENDIX A

Key words searched

“educational game”, “educational gaming”, “educational gaming and health sciences’, simulation and teaching strategy”, simulation AND teaching strategy”.

APPENDIX B

Table: 2. Data abstraction table of primary and secondary articles for key search terms educational game and educational gaming.

Author/ Year/ Country	Study design and sample size	Game format employed	Ranking	Outcomes/Major findings
Abdulmajed et al., 2015 U.S.A	Systematic review of literature including two experimental pre-post-test studies, three observational. (n= 5) papers	Two studies involved board games and other three involved card games, crossword puzzles and a quiz.	III	Knowledge, skills, attitudes, and satisfaction were used as outcome measures. Positive outcomes were noted overall. Four studies reported improved students' knowledge, awareness, and satisfaction. One study reported no significant difference in pre-test and post-test knowledge scores. However, no statistical test was provided.
Akl et al., 2010 U.S.A	Systematic review of randomized controlled trials (RCTs), to assess the effectiveness of educational games. (n= 5) RCTs	Studies were classified according to SR's methodological criteria, including randomized controlled trials (RCT), controlled trials, and interrupted time series. Study participants included students only. Types of intervention were board games, Jeopardy-style game, Charades game, computer game	I	Outcome of interest were students' knowledge, satisfaction, skills, attitudes and behaviour. Three papers reported positive outcomes on knowledge, although one study did not provide statistical testing. Two studies reported no statistically significant effect on knowledge or attitude.
Anyanwu, 2014 Nigeria	Experimental pre-test-post-test design (n=95)	Board game to learn Anatomy. Comparison of game group and non-game group pre-test-post-test knowledge scores. Written pre-test exam was conducted and a 20-item questionnaire rated on a three-point scale to assess student's perception was given to game group.	II	Outcomes of interest were knowledge scores. The post-test scores in the game groups were significantly higher than the pre-test scores and the results were statistically significant ($p < 0.005$). In addition, the post-test score of the game group was statistically better ($p < 0.05$) than their pre-test. Moreover, difference in mean post-test knowledge scores in game group was significantly higher than the mean knowledge post-test scores in the non-game group, and the results were statistically significant ($p < 0.005$). Furthermore, participants from the game group reported positive influence on performance, attitude, team work, feedback, and interest in the course.

Ranking system source employed: Bartfay W.J., & Bartfay, E. (2015). Essential research methods for the practice of public health. *Public health in Canada* (U.O.I.T., ed., pp. 189-233). ISBN: 978132301471. Boston:MA. Pearsons.

Table: 2. Continue...

Author/ Year/ Country	Study design and sample size	Game format employed	Ranking	Outcome/Major findings
Gipson, 2013 U.S.A	Quasi experimental design/Post- test only with only two student groups e.g., lecture group (n=51), and game group (n=53).	Comparison of board game group (i.e. Renal Nephron board game played with 120 multiple –choice questions, true/false, fill-in-the-blank about renal system pathology) with lecture group (i.e., course textbook/slide handouts used in lecture intervention) to assess learning outcomes.	II	Students' knowledge and comprehension about renal system was tested by 63-item examination. Focus was on disease pathology, treatment, diagnostics and nursing care. The study reported lecture group scored higher (mean, 81.95 [SD, 7.37]), on the 100-point examination than the game group (mean, 81.47[6.43]). The difference, however, was not significant ($t = -0.352$). Moreover, the gaming group had a higher GPA (mean, 3.52[SD, 0.37]), than the lecture group (mean, 3.39 [SD, 0.37]), and this difference was significant ($U=1053.5$). In addition, Student Instructional Report II (SIRII) was used to measure student satisfaction in communication, faculty/student interaction, class outcomes, and overall evolution of the class. No difference was reported between the levels of satisfaction between the two groups. Both groups were equally satisfied with their learning outcomes. Furthermore, students from game group commented that they enjoyed the change from traditional lecture format teaching.
Hannig et al., 2012 Germany	Experimental pretest-post- test study design (n=41)	To assess the effects of a serious game eMedOffice on knowledge, problem- solving skills of students	II	Study assessed learning outcomes such as development/ understanding of the concepts i.e., how to start a medical practice (eMedOffice game) and problem-solving skills after playing serious game. A 22-item usability questionnaire survey (used to assess the application of game to the real-world environment) indicated very good overall score of 4.07 (5=best, 1=worst). A second self-report evaluation was conducted to see if game supported the learning process. A third self-report evaluation was conducted to assess knowledge after playing serious game. Significant differences in mean values of pre –and-post-test were noted. The results were statistically significant ($p < 0.001$) for all three assessments. Hence, study concluded that game improved the abilities and knowledge of students. Statistical test paired t test value, however, was not reported

Ranking system source employed: Bartfay W.J., & Bartfay, E. (2015). Essential research methods for the practice of public health.

Public health in Canada (U.O.I.T., ed., pp. 189-233). ISBN: 978132301471. Boston:MA. Pearsons.

Table: 2. Continue

Author/ Year/ Country	Study design and sample size	Game format employed	Ranking	Outcome/Major findings
Jirasevijinda et al., 2010 U.S.A	Cross- sectional (n=34) 54% were male and 46% were female	A Jeopardy inspired game “Bronx Jeopardy” was employed to aid in the delivery of family medicine curriculum to trainees students in an academic program. The game was employed using one Power Point projected on a large screen which consisted of questions from five different categories.	IV	Jeopardy-type game was helpful in teaching trainees new knowledge about their community health status. All participants reported that it was an effective way of learning and they enjoyed the game. Moreover, participants also reported that game stimulated interest to learn new information about their community. They also noted that the game would help in knowledge retention. In addition, game also helped to work in teams, and 40% participants reported that they will apply the knowledge in a real-world setting. The information was collected using a 12-item questionnaire regarding the training session using 5-point Likert scale. Eighty eight percent participants rated agreed (Agreed = 4 & above on the Likert scale) with the knowledge provided in Jeopardy-type game session. No statistical test was provided.
Khan et al., 2011 Saudi Arabia	Parallel group randomized control trial (RCT)/ (n=82). Lecture group (n=41) Game group (n=41)	Comparison of Jeopardy- type game and lecture format in improving knowledge, retention and satisfaction. Game was employed using Microsoft Power Point program. Satisfaction survey was conducted using 5-Point Likert scale (1= strongly disagree, 5 strongly agree).	II	Student’s knowledge, retention, and satisfaction regarding viral exanthema topic. Study reported no significant difference between the post-test I knowledge scores of both groups (i.e., game format mean pretest = 10.9, mean post-test I = 18; lecture format mean pretest I = 10.2, mean post-test I = 17.7). These results revealed that both the teaching strategies to be equally effective in improving knowledge of viral exanthema in the post-test I. However, post-test II conducted after 2 months showed students in game format performed better (mean post-test II score =16.6) than lecture group (control) (mean post-test II scores =13.6) (CI: -3.447-0.455, t: 2.5). This shows that game helped the students in game format to retain the information longer. The results were statistically significant (p = 0.01). In addition, the satisfaction survey reported that the game format was perceived more enjoyable (mean 4.17, SD 0.77) than lecture format (mean 2.80, SD 1.28) (CI: 0.899 -1.833, t: 5.823) and preferred format by the students. These results were also statistically significant (p<0.000).

Ranking system source employed: Bartfay W.J., & Bartfay, E. (2015). Essential research methods for the practice of public health. *Public health in Canada* (U.O.I.T., ed., pp. 189-233). ISBN: 978132301471. Boston:MA. Pearsons.

Table: 2. Continue...

Author/Year/ Country	Study design and sample size	Game format employed	Ranking	Outcome/Major findings
Miralles et al., 2013 Spain	Experimental pretest- post-test. Sample size: (n=36). n=12 majors (at least 24 previous credits in genetics, molecular genetics, molecular evolution), and n=24 non majors (graduates in biology or related sciences with less than 12 credits in genetics)	“DNA Re- Evolution” a molecular genetics board game played by university students in majors and non-majors groups	II	Acquire new knowledge. The difference between pre- and post- tests was highly significant for both majors and non-majors (Paired t-tests yielded $t = 3.20$ and 7.34 and the difference were statistically significant ($p < 0.0047$ and 0.0001) respectively.
Rondon et al., 2013 Brazil	Randomized post-test only Sample size: (n= 29) second-year speech- language and hearing sciences students Group I (computer game- based learning CGBLM n= 15), Group II (Traditional learning method TLM n= 14).	Comparison of computer-based educational game with a traditional. Game involved a quiz containing animations, chapter support, and self-study quizzes. Traditional teaching method involved reading assigned text.	II	Knowledge gain. Short-term and long-term knowledge retention. Study reported no significant difference between the groups related to the learning method ($p=0.176$). However, long-term post-test scores were higher in traditional learning method group only. Pre and post-test knowledge scores in anatomy section were better in computer game group than in traditional learning method group and the results were statistically significant ($p < 0.001$). However, only traditional group performed better in physiology knowledge pre and post-test scores and the results were statistically significant (GI- $p < 0.064$; GII - $P = 0.019$). It should be noted that sample size is too small, hence the study may not be adequately powered to detect significant differences.

Ranking system source employed: Bartfay W.J., & Bartfay, E. (2015). Essential research methods for the practice of public health. *Public health in Canada* (U.O.I.T., ed., pp. 189-233). ISBN: 978132301471. Boston:MA. Pearsons.

Table: 2. Continue...

Author/ Year/ Country	Study design and sample size	Game format employed	Ranking	Outcome/Major findings
Selby et al., 2007 U.K	Experimental study design; (n= 100) Random allocation Group A (n= 48) (interactive lecture) Group B (n=52) (game group)	Comparison of an interactive lecture with a card game 'Development charades' used to role- play characters of the game. A quiz was filled out after the sessions to assess students' short- term retention.	II	Short-term and long-term retention of Knowledge scores. Performance scores. Student in interactive lecture group had significantly higher short-term knowledge retention scores t test= 43.6 (95% CI 17-70); than group B (t test= 37.15 (95 % CI 11-63) and the results were statistically significant (p<0.01, r=0.23). However, developmental examination score was not significant between the two groups.
Shiroma et al., 2011 U.S.A	Randomized pretest- post-test experimental design; (n= 43). Interventional group (n= 29); Lecture group (n= 14)	Comparison between Jeopardy-type educational game and a lecture format. Game was played using a Power Point grid and multiple choice question formats.	II	Knowledge scores. Students perceived game method as more enjoyable (p=0.005), stimulating interest (p=0.004), and increased general knowledge of subject (p=0.025). However, no statistically significant was found between groups in mean pretest-post-test scores. Students also rated the game approach higher than the lecture format.
Swiderska et al., 2013 U.K	Randomized controlled trial (RCT) design; (n= 67). Intervention group (n=31), and control group (n = 36).	Students played a board game "Neonatology" in the intervention group the help of cards and dice.	II	Neonatology knowledge scores. Students' learning experience. Knowledge scores were 4.15 points higher in the game group in comparison to the control group (95% CI -0.88-9.17; cluster 1 intervention group mean: 62.6, [SD, 8.9], cluster 1 control group mean: 61.0, [SD, 6.1], cluster 2 intervention group mean: 66.2, [SD, 4.6], cluster 2 control group mean: 59.1, [SD, 7.6], cluster 3 intervention group mean: 61.0 [SD, 8.5], cluster 3 control group mean: 58.6 [SD, 3.8], cluster 4 intervention group mean: 69.2 [SD, 8.5], cluster 4 control group mean: 63.4 [SD, 3.4]). The results were not statistically significant (p=0.09). However, game was perceived as useful, fun and interesting way to learn by game group.

Ranking system source employed: Bartfay W.J., & Bartfay, E. (2015). Essential research methods for the practice of public health. *Public health in Canada* (U.O.I.T., ed., pp. 189-233). ISBN: 978132301471. Boston:MA. Pearsons.

Table: 2. Continue...

Author/ Year/ Country	Study design and sample size	Game format employed	Ranking	Outcome/Major findings
Schuh et al., 2008 U.S.A	Experimental pretest-post-test only (n= 37) (Game group n= 17) (Control lecture) group n= 20	Comparison of two different teaching strategies (i.e., gaming and weekly oral quizzing and faculty-based didactic lectures) in providing neuroscience residents instructions about basic and clinical neuroscience topic. The control group received 1-hour lecture on the same topic. No description on game was provided. Study only stated that the game was a show-type game.	II	Primary outcome measure was the Students' performance score on the Residency Inservice Training Examination (RITE) program. The study reported that the mean \pm standard error neurophysiology subset percent correct RITE scores was higher in game group (63.6 ± 4.12) than the control group (49.4 ± 2.35). The results were statistically significant ($p= 0.002$). Moreover, the mean yearly percent correct change was also higher for the intervention group (i.e., 19.2 ± 4.24) than the control group (i.e., 8.5 ± 1.44). The results were also statistically significant ($p=0.012$). The Study concluded that interactive game show-type educational intervention was more effective in improving residents knowledge about neurophysiology, and that the study findings can be generalized to other areas of neurology education. However, generalizability of this study can be questioned due to small sample size.
Webb et al., 2012 U.S.A	Experimental pretest-post-test design (n=8)	Jeopardy-type game as a primary instructional technique to teach geriatrics to surgery residents. Pretest 3 days before the gaming session and post-test after 9.2 (range, 5-12) weeks. Cumulative average percent correct was compared between pretests and post-tests using student t test. Participants also evaluated session using Likert scale ratings to rate educational value of the session.	II	Geriatric knowledge scores. Study noted significant increase in retention of geriatric knowledge with an average score of 82.6% (SD, 9.7) following the Jeopardy type game session. The results were statistically significant ($p=0.027$). The difference between overall post-test scores and delayed post-test scores was, however, not statistically significant ($p = 0.079$). Moreover, participants reported high level of satisfaction with both game session and its content with average rating of 4.9 (SD, 0.2) on a scale of 1-5 where 5 = outstanding). Overall, quiz type game as a primary instructional strategy was effective in improving knowledge and its long-term retention. Student t test value was not provided.

Ranking system source employed: Bartfay W.J., & Bartfay, E. (2015). Essential research methods for the practice of public health. *Public health in Canada* (U.O.I.T., ed., pp. 189-233). ISBN: 978132301471. Boston:MA. Pearsons.

APPENDIX C

Table: 4. Data extraction table of primary and secondary articles for key search term simulation and teaching strategy.

Author/ Year/ Country	Study design and sample size	Simulation format applied	Ranking	Outcomes/Major findings
Beyer, et al., 2012 U.S.A	Experimental pretest-post-test design/ (n=45) Tool: Paired t-test	Simulation-based classroom teaching.	II	Knowledge gain. Positive outcomes were noted. Students learning scores were statistically significant [$r(44) = 4.2, p=0.0001$] Students reported positive experience of simulation-based classroom teaching tool. Moreover, students further reported that they liked the simulator experience more valuable experience than the clinical experience and that they would want more simulator experience.
Cant et al., 2010 Australia	Systematic review of experimental or quasi- experimental studies (n=12) studies	All 12 studies reported using simulation as a teaching/learning study	I	Medium and/or high fidelity simulation using manikins is an effective teaching and learning method. Simulation may have advantage over other methods depending on context, topic, and method.
Cooper et al., 2011 Australia	Systematic review of literature from 2000 to 2010 (n=24) studies. All studies were quantitative reports	Obstetrics emergency training using high/low fidelity simulation technique and role- play	I	Multi-disciplinary, simulation based, obstetric emergency training was potentially useful for reducing errors. Studies reported positive outcomes effects of simulation-based training including positive appraisal by students, increased knowledge/skills and improved behaviour

Ranking system source employed: Bartfay W.J., & Bartfay, E. (2015). Essential research methods for the practice of public health. *Public health in Canada* (U.O.I.T., ed., pp. 189-233). ISBN: 978132301471. Boston:MA. Pearsons

Table: 4. Continue...

Author/ Year/ Country	Study design and sample size	Simulation format employed	Ranking	Outcome/Major findings
Gibbs et al., 2014 USA	Experimental two-group pretest-post-test design	Comparison of two teaching strategies in diabetic education. One strategy utilized human patient simulator with a single case study	II	Critical thinking skills, clinical performance. The post-test results were higher in case study group than the simulation group and the results were statistically significant ($p=0.04$). Simulation group scored higher in clinical evaluation tool and the results were statistically significant ($p<0.001$). Overall both teaching strategies were beneficial. However, students in the simulation group reported that simulation was an effective learning tool ($p < 0.03$).
Lancaster, 2014 USA	Experimental pretest and post-test design (n= 79) Female =88% Male = 12%	Serious game (SG) simulation as a teaching tool in third year students. Students completed 11-question post-test and demographic survey and self-confidence in learning scale tools.	II	Students' knowledge s, self-confidence and satisfaction, problem-solving skills, feedback, support and realism. Significant increase in knowledge scores was noted from pre-simulation to post-simulation test and the results were statistically significant [$t(78) = -2.651$; $p<0.01$]. Students also supported satisfaction with achievements on problem-solving skills, presence of feedback and support, and realism of the simulation scenarios.
Sinclair, 2009 Canada	Experimental pre/post-test mixed method. (n=174) (Intervention group n= 74) (male n=3; female n=71) (Control group = 100) (male n= 6; female n= 94)	A mid fidelity mannequins and role-playing was used to create nursing scenarios for the intervention group. There was also a lecture component in intervention group. To assess the effectiveness, students filled pre-and post-lecture or simulated session.	II	Students' knowledge and satisfaction scores. Scores for all scenarios improved significantly, except one ($p<0.218$). Moreover, 91 percent students from intervention group reported simulation-based learning activity was effective or highly effective. Whereas, 68 percent of students from control group reported lecture only to be effective or highly effective for their learning. Over all, students were more satisfied and confident in the combined lecture/simulation learning activities (91% consistency between simulated-based activity and learning style), in comparison to lecture only group (76% consistency between lecture method and learning style). Confidence and engagement level among students was also reported to be very high following the simulation-based learning activity.

Ranking system source employed: Bartfay W.J., & Bartfay, E. (2015). Essential research methods for the practice of public health. *Public health in Canada* (U.O.I.T., ed., pp. 189-233). ISBN: 978132301471. Boston:MA. Pearsons

Table: 4. Continue...

Author/ Year/ Country	Study design and sample size	Simulation format employed	Ranking	Outcome/Major findings
Tawalbeh et al., 2014 Jordan	Randomized control trial (RCT) (pretest-post-test design) (n=82) (Intervention group n= 40) (Control group n= 42)	To assess the effect of two different strategies i.e., simulation scenarios with four-hour Power Point presentation, and a demonstration on a static mannequin (intervention group) and Power Point presentation and a demonstration only (Control group) on the knowledge and retention of nursing student.	II	Students' knowledge, retention and confidence. Students' knowledge, confidence and retention were higher as compared to control group following the simulation-based scenarios. The results were statistically significant for knowledge ($p<0.001$), confidence ($p<0.001$) and retention ($p<0.001$).
Tiffen, 2009 U.S.A	Experimental study design Randomized control trial (RCT) (n=32) (intervention group n=18) (Control group n=14)	Comparison of 1-hour simulation experience focusing on cardiac and respiratory assessment (intervention group) with usual course lecture and laboratory material (control group).	II	Acquisition of basic skills and enhancement of confidence. Significant difference was noted between the intervention and control group in acquisition of basic skills and confidence. The results were statistically significant ($f(6-25) = 7.544$, $p<0.001$).

Ranking system source employed: Bartfay W.J., & Bartfay, E. (2015). Essential research methods for the practice of public health. *Public health in Canada* (U.O.I.T., ed., pp. 189-233). ISBN: 978132301471. Boston:MA. Pearsons

APPENDIX D

A description of the ranking hierarchy employed

Level	Description
I	Highest ranking: Systematic reviews of RCTs and non-randomized control trials
II	Single RCT or non-randomized trial
III	Systematic reviews of observational and/or correlational studies
IV	Single observational or correlation study
V	Systematic reviews of a physiological, descriptive, or qualitative study
VI	Single physiological, descriptive, or qualitative study
VII	Lowest ranking: Opinions by experts in their noted field, panels or committees.

Source: Adapted from Bartfay W.J. & Bartfay, E. (2015). Public Health in Canada: Essential Research Methods for the Practice of Public Health. Toronto, ON: Pearsons.

APPENDIX E

Glossary of key terms

Analysis of variance (ANOVA): A statistical procedure for testing mean differences among three or more groups by comparing the variability between the groups to the variability within them (Polit & Beck, 2014).

CD-ROM: A compact disc used as a read-only optical memory device for a computer system (Oxford dictionaries, 2015)

Correlational research study: Research that explores the interrelationships among variables of interest without any active intervention on the part of the researcher (Polit & Beck, 2004).

Control group: Subjects in an experiment who do not receive the experimental treatment and whose performance provides a baseline against which the effects of the treatment can be measures (Polit & Beck, 2004).

Database: A collection of data or information stored in a computer. You can think of it as an electronic filing system (Godshall, 2010).

Descriptive research study: Research studies that have as their main objective the accurate portrayal of the characteristics of person, situations, or groups, and/or the frequency with which certain phenomena occurs (Polit & Beck, 2004).

Experiment: A research study in which the investigator controls (manipulates) the independent variable and randomly assigns subjects to different conditions (Polit & Beck, 2004).

Game: An activity or contest with a goal involving rules in which one or more people engage to have fun (Baranowski et al., 2008).

Generalizability: The degree to which it can be inferred that the findings can be generalized from a sample to a population (Polit & Beck, 2004).

Instrument: The device that a researcher uses to collect data (e.g., questionnaires, scales, observation schedules, etc.) (Polit & Beck, 2004).

Intervention: In experimental research, the experimental treatment or manipulation (Polit & Beck, 2004).

Likert Scale: A composite measure of attitudes that involves summation of scores on a set of items (statements) to which respondents are asked to indicate their degree of agreement or disagreement (Polit & Beck, 2004).

Millennial: A person reaching young adulthood around the year 2000 (Oxford dictionaries, 2015).

Observational research: Studies in which the data are collected by observing and recording behaviours or activities of interest (Polit & Beck, 2004).

P value: In statistical testing, the probability that the obtained results are due to chance alone; the probability of committing a Type I error (Polit & Beck, 2004).

PDA: A palmtop computer that functions as a personal organizer but also provides email and internet access (Oxford dictionaries, 2015).

Post-test: The collection of data after the introduction of an experimental intervention (Polit & Beck, 2004).

Post-test only: An experimental design in which data are collected from subjects only after an intervention has been introduced; also referred to as an after-only design (Polit & Beck, 2004).

Pretest: The collection of data prior to the experimental intervention; sometimes referred to as baseline data (Polit & Beck, 2004).

Random assignment/Randomization: The assignment of subjects to treatment conditions in a random manner (i.e., in a manner determined by chance alone) (Polit & Beck, 2004).

Serious game: A videogame that uses computer-based entertainment technology to teach, train, or change behavior (Baranowski et al., 2008).

Videogame: A game interactively played with visual (and often audio) components on some digital device (Baranowski et al., 2008).